CLAIMS

I claim

1. An improvement in a system for determining the location of at least one point-like radiator of energy in a coordinate system by sensing the radiator using at least one camera containing an array of photosensitive pixels, in which the pixel location of the image of the radiator is determined, so that a radiator location computing means can calculate the location of the radiator itself within the coordinate system from the image location or locations, where the improved system comprises

at least one said point-like energy radiator;

at least one said camera comprising

an image forming means, an image reshaping means, and a pixel array,

wherein each pixel array is an array of energy sensitive detectors;

an image processing means to compute the location of the image of the radiator on each pixel array by identifying the center or some other reference point on the image to a precision of smaller than the size of each pixel; and

said radiator location computing means to calculate the location of the radiator in the coordinate system, given the subpixel location of each image and a calibration function mapping said radiator image locations to the radiator location.

2. The system of claim 1, wherein said energy is visible light or is infrared light.

3. The system of claim 1, wherein said radiator is a light-emitting diode, commonly known as an LED.

4. The system of claim 1, wherein said radiator is a retro-reflector, which reflects energy back toward the sensor from a source of said energy near the line of sight of each said sensor.

5. The system of claim 1, wherein said image forming means is a system comprising at least one lens.

6. The system of claim 1, wherein said image forming means employs diffractive optics.

7. The system of claim 1, wherein said image forming means is the aperture itself acting in the manner of the pinhole of a pinhole camera, but where the aperture is not an approximation of a single circular transparent disc.

8. The system of claim 1, wherein said image reshaping means is a diffractive filter, of which a holographic filter is a special complex example.

9. The system of claim 1, wherein said image reshaping means is a lens system and aperture designed to introduce a small amount of distortion to reshape a tiny circular spot image into an image which increases the perimeter-to-area ratio of the image by at least 50% and spreads the image over more than 4 non-collinear pixels.

10. The system of claim 1, wherein said image reshaping means is a noncircular aperture.

11. The system of claim 10, wherein the aperture comprises at least one energy transparent area within an energy opaque mask.

12. The system of claim 11, wherein at least one transparent area has a total perimeter-to-area ratio which is at least 50% greater than that of a circular disc.

13. The system of claim 1, wherein said image reshaping means is a diffraction grating.

14. The system of claim 1, wherein said image reshaping means is a holographic filter.

15. The system of claim 1, wherein each pixel array is a charge-coupled device commonly known as a CCD.

16. The system of claim 1, wherein said image processing means employs a correlation function matched to the expected shape of the image of said radiator as imaged by the sensor..

17. The system of claim 1, wherein said image processing means uses some best-fit criterion to map a movable and scalable geometrical entity onto the image on the pixel array, where the entity possesses at least a reference point, which point then defines the location of the image on the pixel array.

18. The system of claim 18, wherein the geometrical entity is a straight line segment.

19. The system of claim 18, wherein the geometrical entity is all or part of a conic section curve.

20. The system of claim 18, wherein the geometrical entity is a polynomial arc.

21. The system of claim 1, wherein the image processing means is an electronic microprocessor.

22. The system of claim 1, wherein said radiator location computing means is an electronic microprocessor.

23. An improvement in a location measurement system, which system comprises

a coordinate system;

at least one point-like radiator of energy within the coordinate system;

at least one energy sensor which forms an image of at least one radiator;

a image processor to find said image in the sensor and to calculate the location of said image in the sensor; and

a radiator location computer to calculate the location of each radiator relative to the coordinate system, given at least one image location and a calibration function mapping at least one said image location to a coordinate set representing the location in the coordinate system;

where said improvement comprises

an image reshaping means in at least one said sensor, such that the image always covers at least 4 non-collinear pixels and the reshaping increases the number of pixels

containing edges of the reshaped image compared to the original image by at least 50%;

such that the image processor is adapted to process a reshaped image generated from the original image by the image reshaping means.

24. The system of claim 23, wherein said energy is visible light or is infrared light.

25. The system of claim 23, wherein said radiator is a light-emitting diode, commonly known as an LED.

26. The system of claim 23, wherein said radiator is a retro-reflector, which reflects energy back toward the sensor from an energy radiator near the line of sight of each said sensor.

27. The system of claim 23, wherein said sensor includes at least one lens.

28. The system of claim 23, wherein said sensor includes diffractive optics.

29. The system of claim 23, wherein said sensor includes an aperture acting in the manner of the pinhole of a pinhole camera, but the aperture is not a single circular disc.

30. The system of claim 23, wherein said image reshaping means is a diffractive filter.

31. The system of claim 30, wherein said filter is a holographic filter.

32. The system of claim 23, wherein said image reshaping means is a lens system intended to introduce a small amount of distortion in order to reshape a tiny circular spot image into an image which increases the perimeter-to-area ratio of the image by at least 50% and spreads the image over at least 4 non-collinear pixels.

33. The system of claim 23, wherein said image reshaping means is an aperture.

34. The system of claim 33, wherein the aperture comprises at least one energy transparent area within an energy opaque mask.

35. The system of claim 34, wherein at least one transparent area has a total perimeter-to-area ratio which is at least 50% greater than that of a circular disc.

36. The system of claim 23, wherein said image reshaping means is a diffraction grating.

37. The system of claim 23, wherein said image reshaping means is a holographic filter.

38. The system of claim 23, wherein each pixel array is a charge-coupled device commonly known as a CCD.

39. The system of claim 23, wherein said image processing means uses a correlation function matched to the expected shape of the image of said radiator as imaged by the sensor..

40. The system of claim 23, wherein said image processing means uses some best-fit criterion to map a movable and scalable geometrical entity onto the image on the pixel array, where the entity possesses at least a reference point, which point then defines the location of the image on the pixel array.

41. The system of claim 40, wherein the geometrical entity is a straight line segment.

42. The system of claim 40, wherein the geometrical entity is all or part of a conic section curve.

43. The system of claim 40, wherein the geometrical entity is a polynomial arc.

44. The system of claim 23, wherein the image processor is an electronic microprocessor.

45. The system of claim 23, wherein said radiator location computer means is an electronic microprocessor.

46. A process for determining the location of a point-like radiator of energy in a coordinate space by forming the image of the radiator in at least one sensor, precisely determining the location of the image of the radiator therein, and calculating the location of the radiator itself within the coordinate system from at least one such image location, where the process comprises

placing a point-like energy radiator in said coordinate space;

forming an image in at least one said sensor

reshaping at least one such image

processing the image to determine its location in the sensor by identifying the center or some other reference point on the image to a precision of smaller than the size of each pixel; and

computing said radiator location coordinates describing the location of the radiator in the coordinate space, when given the subpixel location of sufficient images and given a calibration function mapping the image locations of the sufficient images to the radiator location.